ATTACHMENT C ***EVOSTC Annual Project Report Form***

Form Rev. 10.3.14

1. Program Number: *See*, Reporting Policy at III (C) (1).

15120120

2. Project Title: *See*, Reporting Policy at III (C) (2).

Collaborative Data Management and Holistic Synthesis of Impacts and Recovery Status Associated with the Exxon Valdez Oil Spill

3. Principal Investigator(s) Names: *See*, Reporting Policy at III (C) (3).

Matthew B. Jones

4. Time Period Covered by the Report: *See*, Reporting Policy at III (C) (4).

February 1, 2015-January 31, 2016

5. Date of Report: *See*, Reporting Policy at III (C) (5).

March 1, 2016

6. Project Website (if applicable): *See*, Reporting Policy at III (C) (6).

www.gulfwatchalaska.org

7. Summary of Work Performed: *See*, Reporting Policy at III (C) (7).

Data collection, collation, and assembly for synthesis continued, and closely targeted questions and topics the working groups are studying. Some fisheries independent data was collated, but other requests are still outstanding. Research topics are in different phases; however, data cleaning and preliminary analyses are on-going.

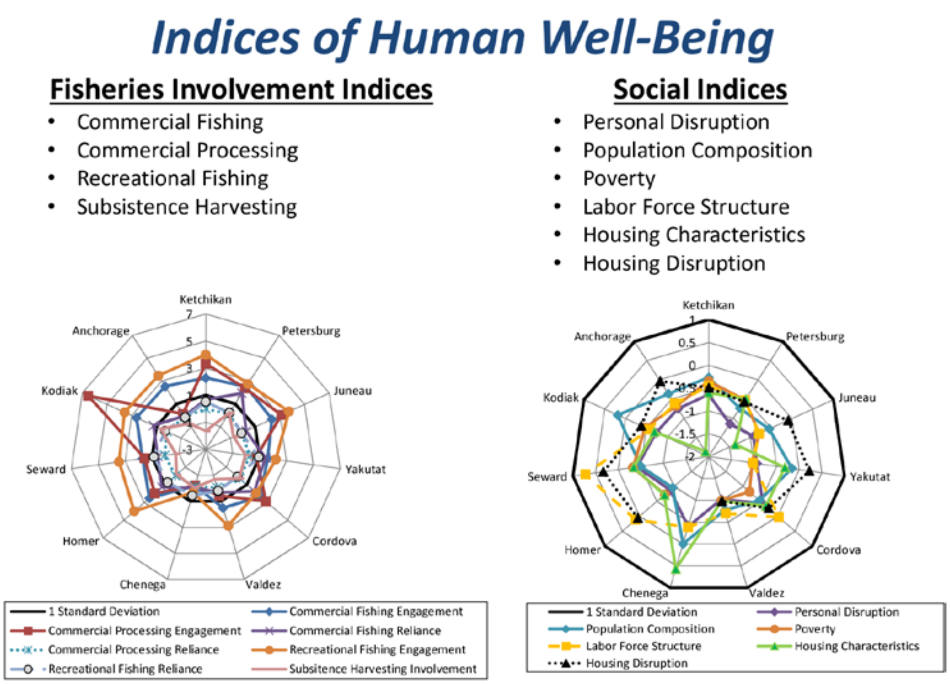
Historical data archiving: Initial efforts to archive historical Gulf Watch Alaska (GWA) program data returned 27% of known data sets; therefore this project was re-invigorated in December 2015. Four student interns have been hired to assist in this effort, and in December we started a new process to prioritize and identify mechanisms to obtain important historical data sets. Couture has identified management team liaisons from each of the major agencies that still hold historical data, including Alaska Department of Fish and Game (ADF&G), National Oceanic and Atmospheric Administration (NOAA), University of Alaska Fairbanks, U.S. Geological Survey (USGS), and Prince William Sound Science Center (PWSSC). Discussions began at the 2015 Alaska Marine Science Symposium (AMSS) to include those managers in priority setting for data recovery, with the plan that the agency researchers will be more responsive when there is support for the activity from within their respective agencies.

A manuscript is in preparation documenting patterns in data recovery. Specifically, we are evaluating whether data type (e.g., oceanographic, fishery), collection agency (e.g., government, academic, non-governmental organization), and data age are correlated with likelihood of recovery.

Synthesis Working Groups: As planned in the previous year, both the Social-ecological Systems working group and the Portfolio Effects working group were convened in FY15, and each held two working group meetings at the National Center for Ecological Analysis and Synthesis (NCEAS) in Santa Barbara, California to further their synthesis goals. The two postdocs associated with these groups (Blake and Ward) also started just before FY15, and so their work is now synchronized and proceeding according to last year's revised plan. Both groups will hold two additional synthesis meetings in FY16, and complete submission of synthesis manuscripts this year. The budget for both the working groups and postdoc activities is being used in years 4 and 5 according to this revised plan. A summary of work from each group follows.

Social-ecological Systems (working group): This working group seeks to understand the relationships between social and ecological systems in the Gulf of Alaska, understand past changes in social-ecological systems, and develop linked social-ecological models to improve management and adaptation to change. The overarching goal is to develop an integrated social-ecological systems model, but the initial approach will build to this goal by examining four component research topics that were developed at the first group meeting in Santa Barbara in February 2015:

(i) Retrospective socio-ecological analysis will examine the historic impacts of the 1964 earthquake and the 1980 *Exxon Valdez* oil spill (EVOS) on social communities in the context of community resilience. Specifically, the group seeks to determine which factors affect the well-being and adaptive capacity of social communities affected by the earthquake and EVOS (Figure 1). A case study approach is being focused on six communities: Valdez, Cordova, Chenega, Tatilek, Kodiak, and Seward. Community profiles have been developed, and are currently under expert review. Community characteristics will be compared to assess what attributes may confer persistence.



(Adapted from Himes-Cornell and Kasperski, 2015)

Figure 1: Indices of human well-being divided into social and fisheries related indices.

(ii) Human responses to ecosystem and management change are being evaluated. Research questions include: How do communities respond to changes at the environmental, ecological, and management levels? What community capital supports resilience (e.g., food and nutrition security)? What are the threats to this capital and implications of those threats to community resilience? Social and economic approaches are being used to answer these questions and look at indirect effects, for example, of changes in fisheries management policy on job and food security. Data collation and preliminary analysis are underway.

(iii) Biophysical drivers of ecological change are being examined at the large scale for the central Gulf of Alaska, and at the smaller scale for PWS for both pelagic and benthic ecosystems. The goals are to identify drivers of seasonal and interannual productivity and variability, characterize stressors on certain focal species/groups of species, and shed light on triggers of tipping points or regime shifts (Figure 2). Ecopath models, which will be used to examine pelagic ecosystems, are currently being re-parameterized as data become ready. Benthic ecosystems will use Structural Equation Models or other community metrics to examine relationships between biological and physical parameters. Approximately 30 unique data sets have been obtained, cleaned, collated, and assembled, and preliminary analyses have begun.

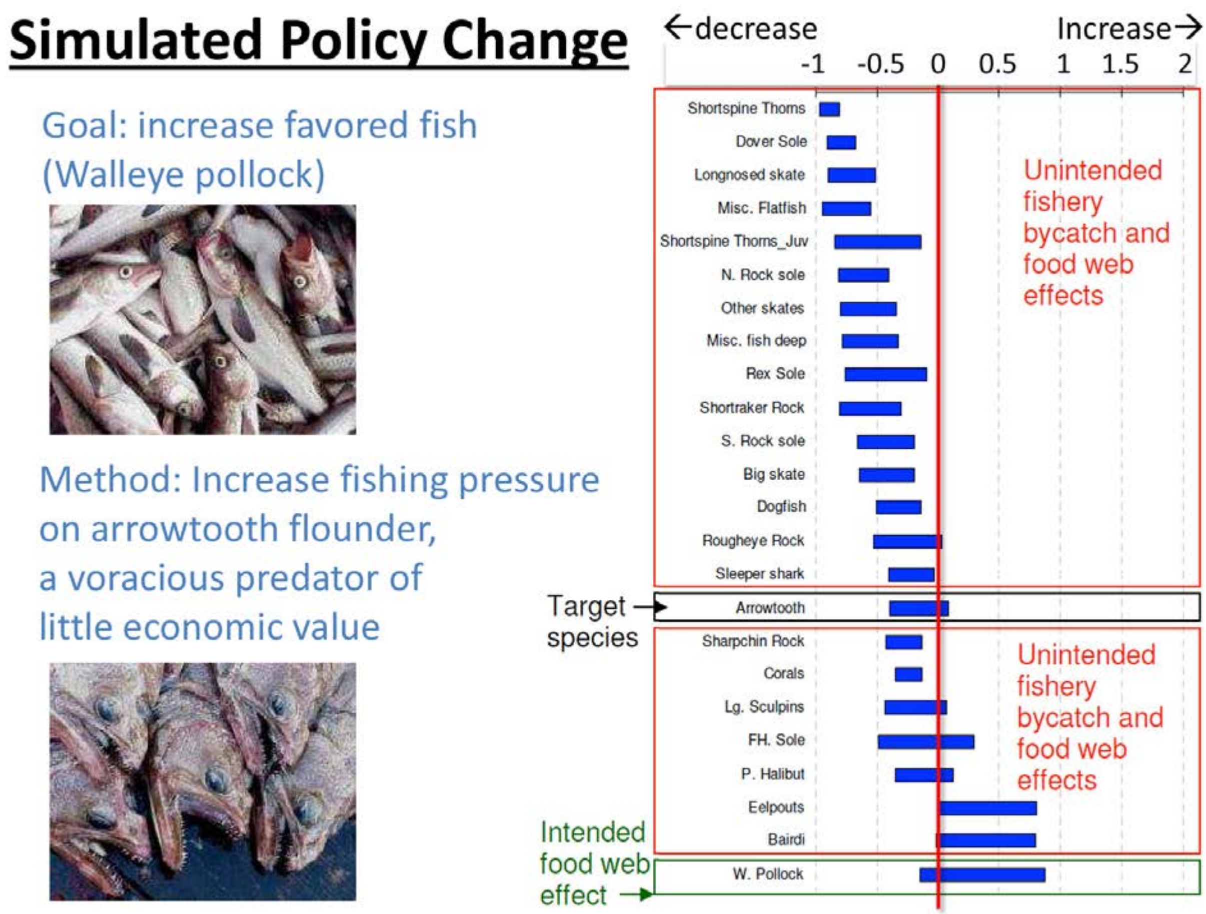


Figure 2: Simulation of policy change for a particular species, and wider unintended impacts in the foodweb. Adapted from Sarah Gaichas.

(iv) Finally, linking human and ecological indicators using model systems seeks to bring the social and biological data together (Figure 3). Specific research questions include: Can we identify linkages and feedbacks between ecological and human systems? Can we characterize how stressors acting on these connections affect human and ecosystem well-being and the strength of the social-ecological system? Can we identify frameworks and methodologies for linking human and ecological systems going forward? Current methods under consideration include Dynamic Factor Analysis, Random Forests, and Structural Equation Modeling. Another 30 unique data sets have been obtained from various sources including government agencies, state agencies, and academic research scientists. Data have been cleaned and unified (homogeneous column headings, uniform data and taxa codes etc.), georeferenced, and assembled into a large data set. Preliminary analyses are on-going and currently in the second phase, with plans for final analyses to start in the spring.

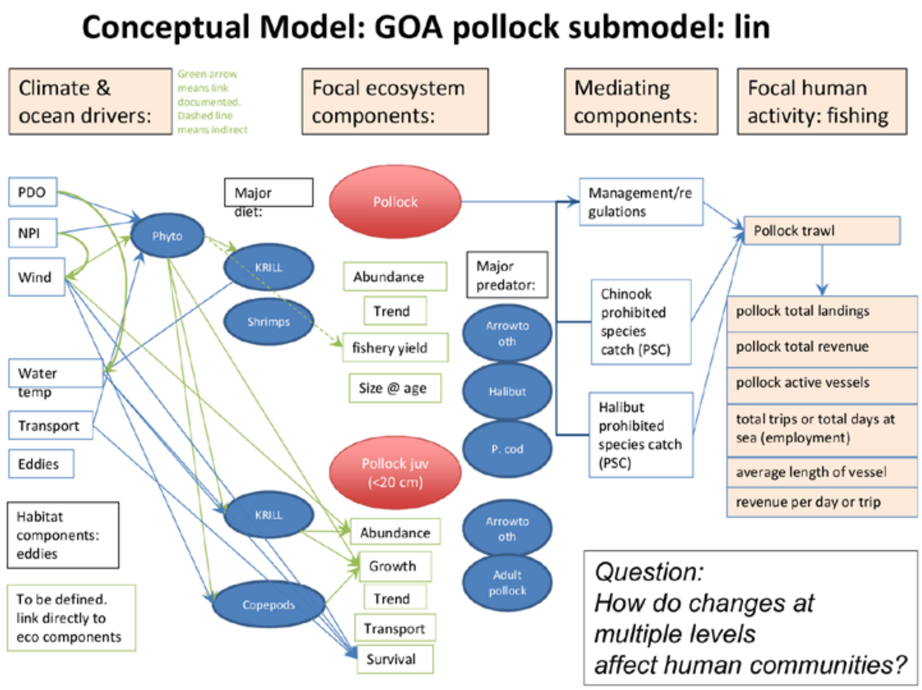


Figure 3: Conceptual model for pollock in the Gulf of Alaska (GOA), linking human activities to ecological components and climate drivers.

Applying Portfolio Effects to the Gulf of Alaska (working group): The overarching goal of this group's research is to assess the relationship between biodiversity and stability of ecological populations and communities, as well as harvest of marine species, in the Gulf of Alaska. This group has five research projects underway in various stages:

(i) Drivers of long-term herring and salmon population dynamics in coastal Alaska. Using data pre- and post-EVOS (Figure 4), this group applied time series methods to evaluate support for how herring and salmon recruitment has been affected by five hypothesized factors: (1) effects of density dependence, or decreasing population growth rate at increasing population density, (2) immediate and/or prolonged impacts of the EVOS event, (3) effects of interspecific competition on juvenile fish, (4) effects of predation from adult fish or other predators, and (5) impacts of changing environmental conditions. The resulting manuscript will be submitted to a journal by Spring 2016.

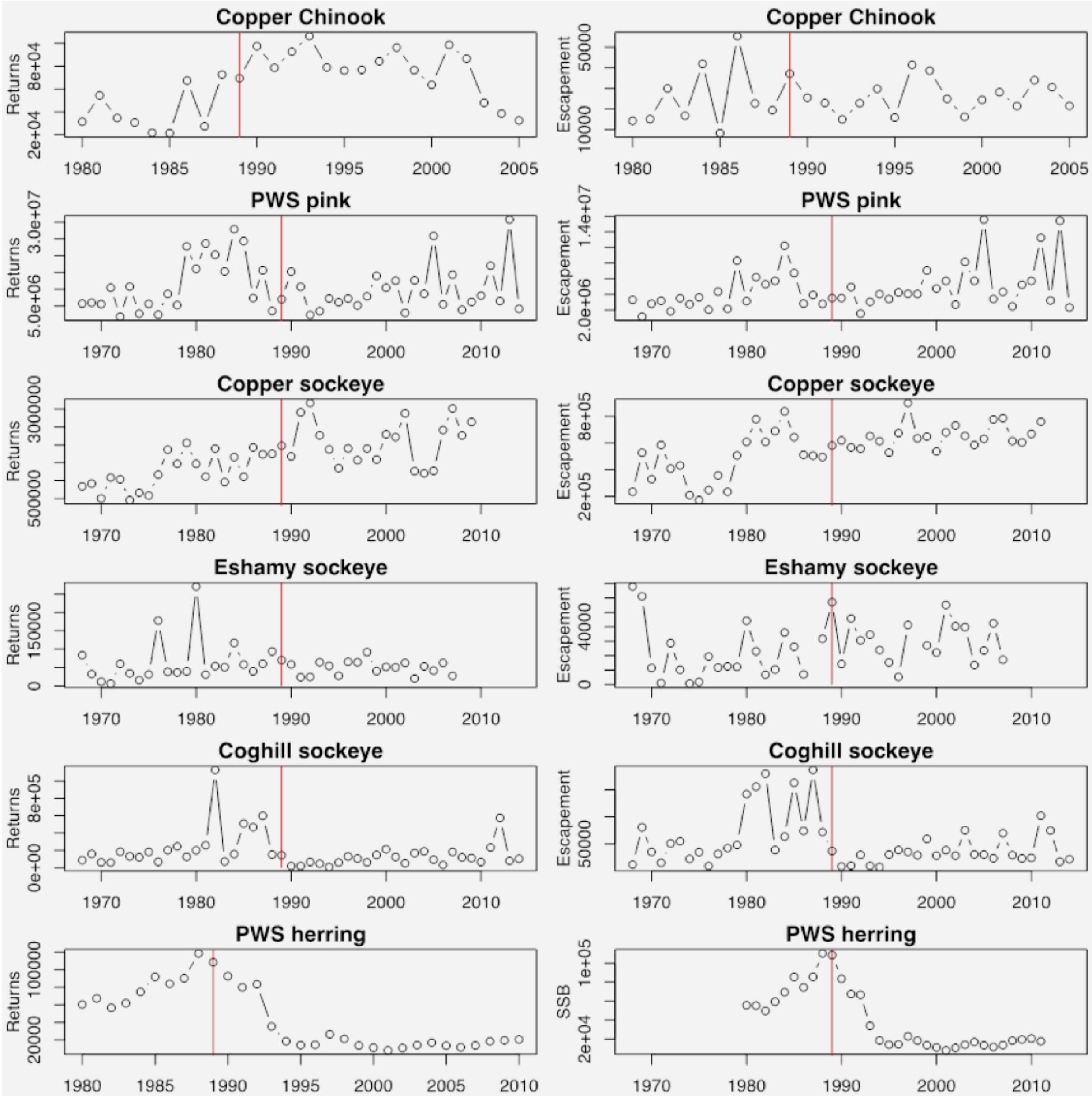


Figure 4. Time series plots of recruitment and spawning stock for herring and salmon in the PWS area. Red line indicates EVOS in 1989.

Assembly of key data sets is nearing completion and analyses are underway for several other projects:

(ii) Subsistence Harvest portfolios. This subgroup is evaluating whether subsistence harvest portfolios showed evidence of resource substitution following EVOS. Specifically, were oil-impacted species replaced with unimpacted species? The group is undertaking a literature review and is currently analyzing community subsistence data (resource use) collected by ADF&G Community Subsistence Information System database from eight coastal regions (Figure 5). Resource use is measured in terms of harvest level, species composition of harvest, and the number of people participating in subsistence activities. Preliminary results suggest that in oil-impacted communities (e.g., PWS; Figure 6) total harvest declined immediately following EVOS and showed some recovery within five years. The greatest decline was observed in the harvest of marine mammals and invertebrates, likely due to food safety concerns and declines in resource availability. There was no evidence of resource substitution, although the harvest portfolio shifted towards fish over time. Preliminary results also suggest that the most pronounced effects were observed in the PWS region; effects on adjacent regions were equivocal.

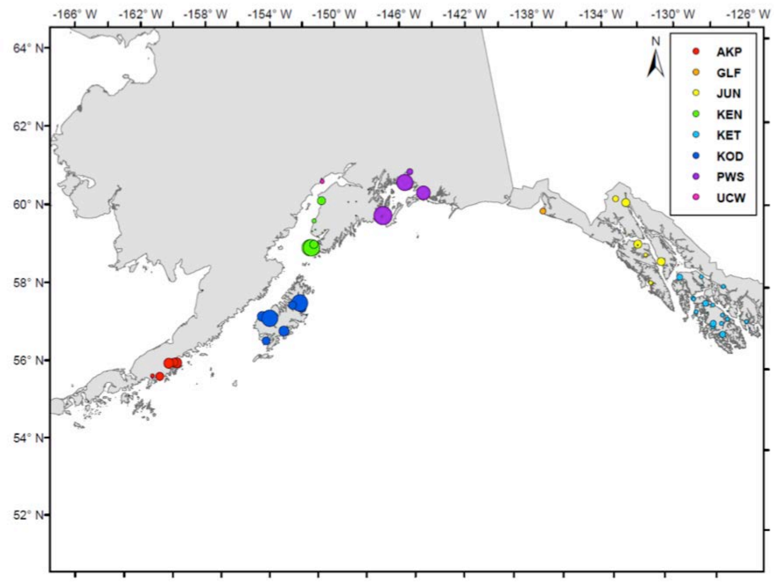


Figure 5. Coastal communities for which subsistence harvest data are being evaluated by the Subsistence Harvest subgroup.

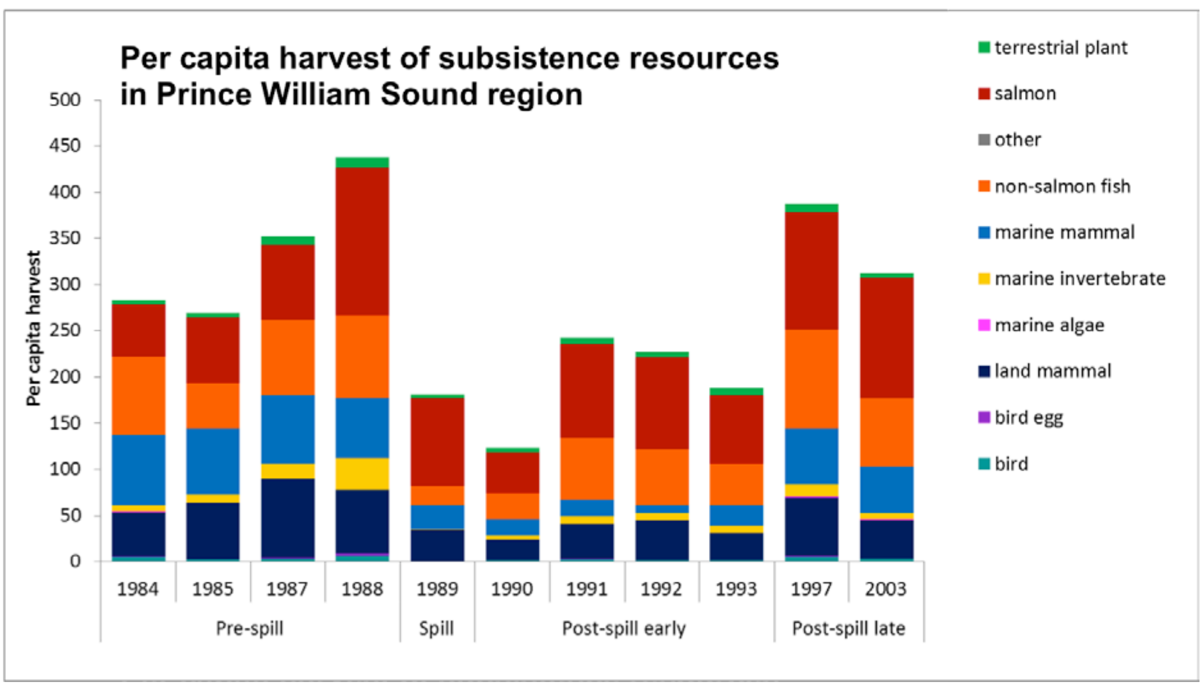


Figure 6. Per capita harvest of subsistence resources in the PWS region, 1984 - 2003.

(iii) Commercial Harvest portfolios. This subgroup is evaluating whether events such as climatic regime shifts and EVOS had detectable effects on the diversity and economic values of commercially harvested species, and whether diverse commercial portfolios buffered fishers against these events. Preliminary results suggest that diversity of species landed by the PWS commercial fishery increased following EVOS (Figure 7), that the value of commercial deliveries becomes less variable as the number of species harvested increases (Figure 8), and that the overall value of the harvest increases with number of species delivered.

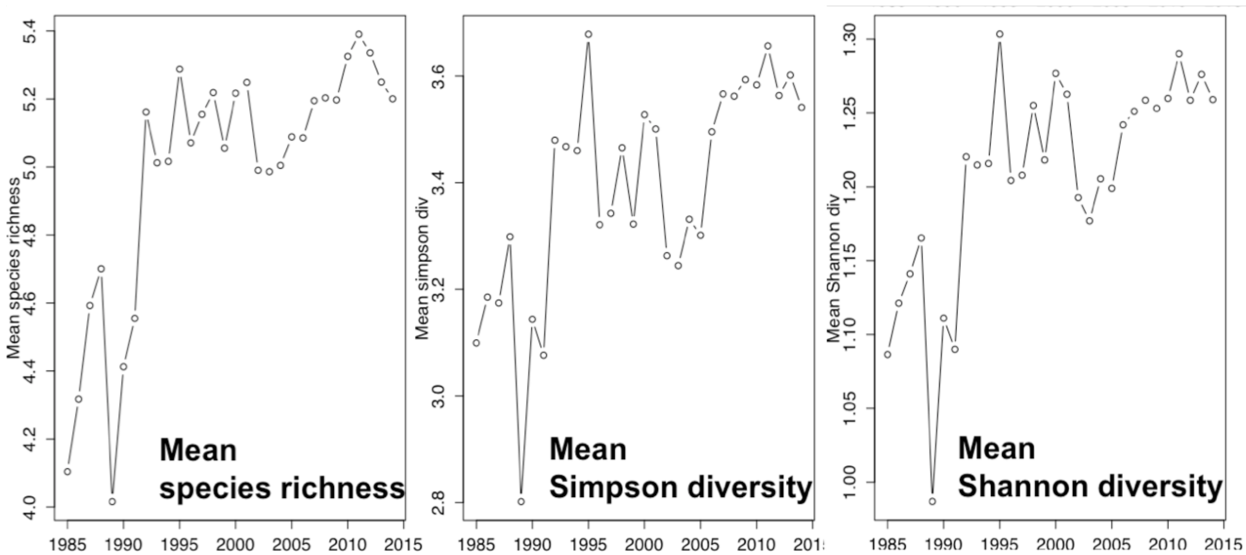


Figure 7. Diversity of species landed by the PWS commercial fishery (annual per vessel commercial deliveries), 1985-2015. Results should be considered preliminary.

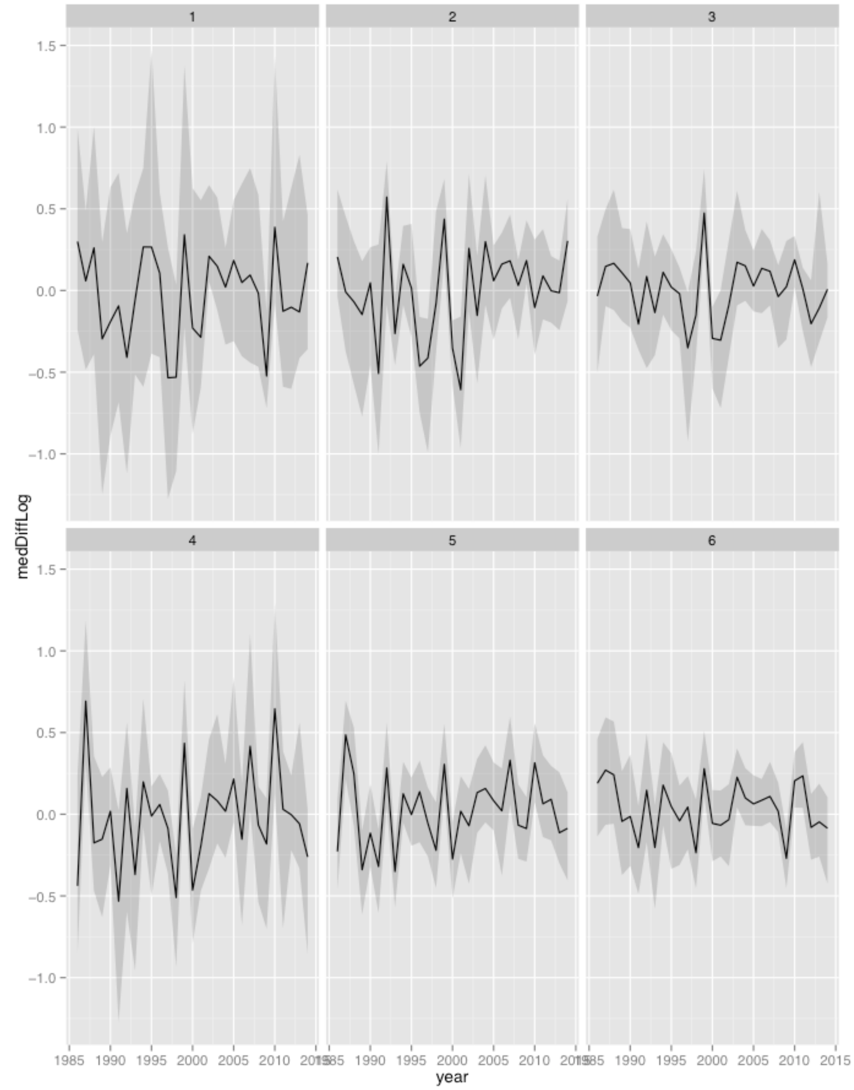


Figure 8. Log difference in earnings for individual vessels in PWS, log et+1 - log e_t (median and quartiles (25/75) across all vessels), 1985-2015. Panels represent the number of species fished in consecutive years (1 = more specialized, 6 = generalist). Results should be considered preliminary.

(iv) Ichthyoplankton. This subgroup is assessing long-term trends in diversity, individual species abundances and occurrences, and synchrony thereof in the spring ichthyoplankton community southwest of Shelikof Strait, using data from NOAA's Ecosystems and Fisheries-Oceanography Coordinated Investigations (EcoFOCI) program collected annually since 1981. The group will also assess whether there was a detectable impact of EVOS and long-term climate indices in these metrics.

(v) Groundfish. This subgroup is evaluating spatio-temporal patterns in occurrence, catch per unit effort (CPUE), and diversity of Alaskan shelf groundfish assemblages. The group has used delta-generalized linear mixed models (delta-GLMM) to estimate occurrence and CPUE across space and time for 54 fish and three crab species representing the most commonly-occurring species in NOAA's bottom trawl survey (Figure 9). Using eleven discrete and roughly comparable areas (50-150m depth) with differing exposure to oil following EVOS (Figure 10), the group is assessing whether there occurred detectable changes in the spatial distribution of groundfish related to EVOS.

The group is also assessing whether responses to EVOS and long-term trends vary with life history characteristics and functional traits. Preliminary results suggest that species abundances were relatively synchronous over time in the eleven discrete areas (Figure 11).

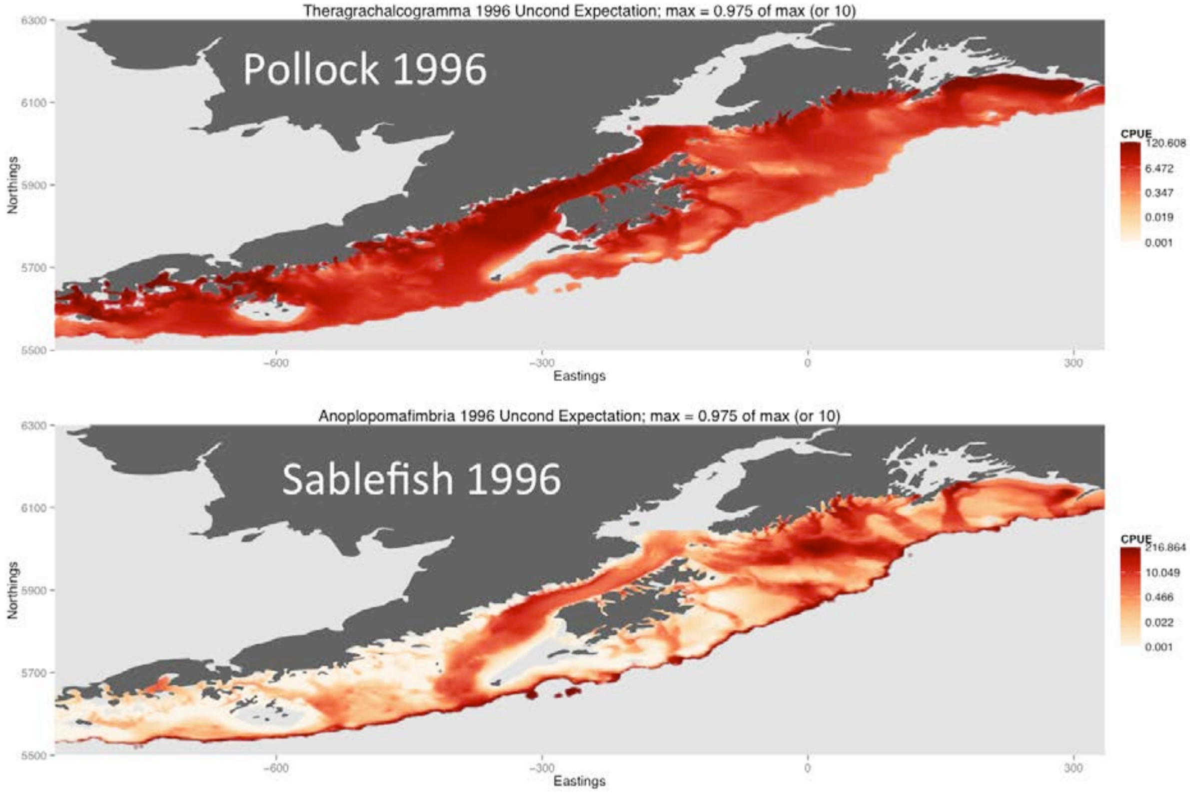


Figure 9. Example delta-GLMM output of 1996 CPUE for walleye pollock (*Theragra chalcogramma*) and sablefish (*Anoplopoma fimbria*).

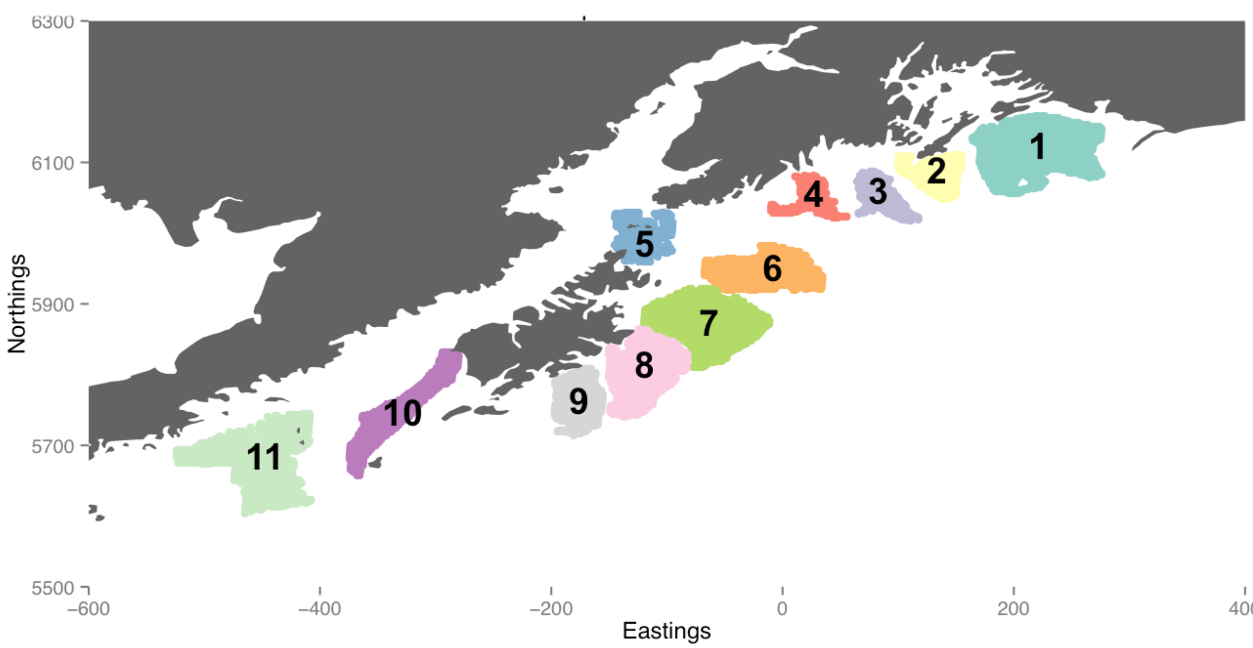


Figure 10. Map of eleven discrete regions with depth 50-150m, exposed to varying levels of oil following the EVOS event.

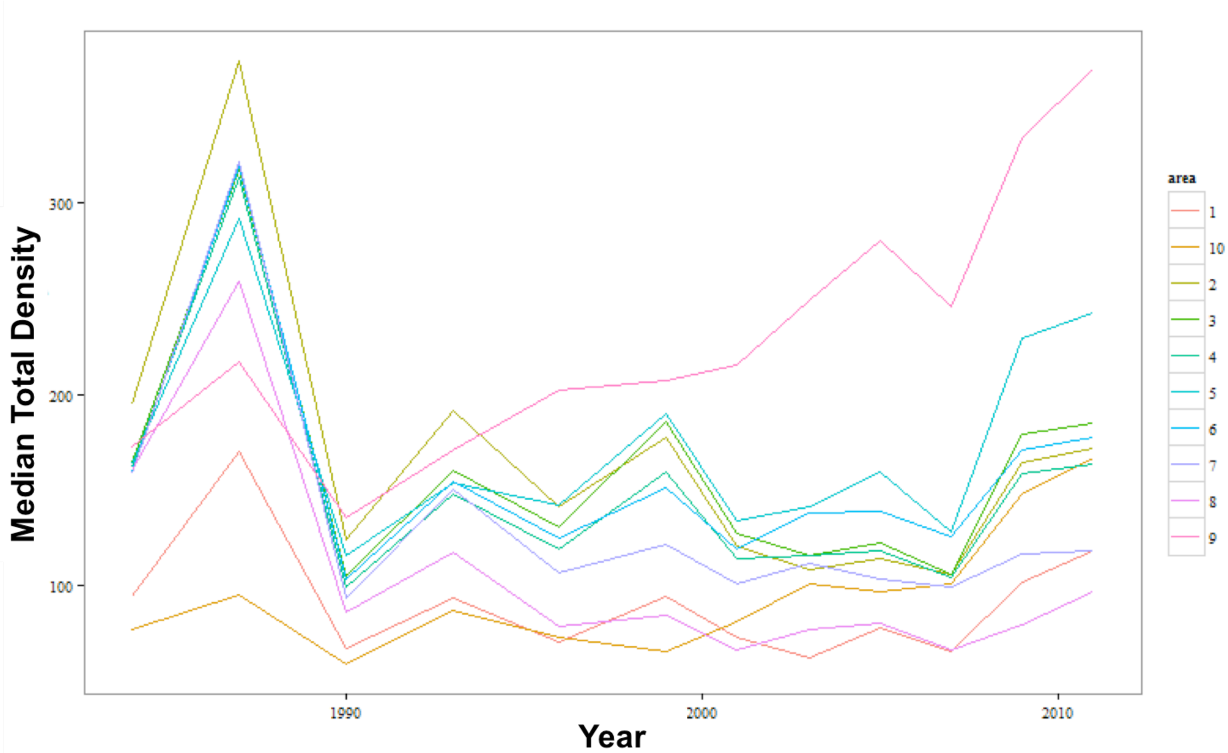


Figure 11. Median total density of groundfish species from delta-GLMM, 1984-2011; area numbers correspond to map in Figure 10. Results should be considered preliminary.

Rachael Blake (post-doc): In addition to facilitating working group projects, Blake's independent project is centered on understanding the relative importance and impacts of multiple stressors for nearshore ecological communities in the Gulf of Alaska. The largest effort this year has gone into finding a geographic area and ecosystem that has been sampled across many levels of biological organization in concordant time steps. The focal area is PWS because data on organisms from plankton to mammals have been collected historically and in on-going sampling efforts in nearshore habitats. So far, data for nearshore vertebrate predators, ducks, and invertebrates have been located and obtained. Data from the mid-1990s was obtained most recently and is still in raw form awaiting cleaning that will unify column names, standardize taxa codes, and georeference sampling locations. Data from the ongoing GWA program (http://www.gulfwatchalaska.org/) has generally been obtained (but still missing data for some taxonomic groups) and has been cleaned as above. Oceanographic and climate data have also been downloaded from NOAA websites. Together these data comprise about 30 unique data sets that have been cleaned, assembled, and collated in preparation for analysis. This effort was aided by working group members who work in PWS. The analysis approach is to use multivariate analyses to examine research questions such as: What are the impacts of extreme physical stressor events for the benthic infaunal community? How do biological and physical stressors interact? Does stressor relative importance and impact vary through time? Data cleaning is in the final stages, and preliminary analysis has started.

An additional project is on-going, examining the hurdles to conducting large-scale collaborative synthetic analyses. This work is a joint effort of the two post-docs (Blake and Ward), as well as data manager (Couture). We have hosted two roundtable discussions:

(http://roundtable.nceas.ucsb.edu/2015/07/01/july-7-discussion-about-hurdles-to-synthesis-and-navigating-collaborations-in-working-groups/ and http://roundtable.nceas.ucsb.edu/2016/01/05/synthetic-ecology-across-scales-a-follow-up-discussion-on-hurdles-to-synthesis/) with the NCEAS community to draw on the wider experience of research scientists and staff in facilitating scientific collaborations. We also presented a poster at the Coastal and Estuarine Research Federation meeting in Portland, Oregon in November 2015 titled Synthetic ecology across scales: a Gulf of Alaska case study in the session called "Estuarine and coastal data-centric synthesis studies: case studies and pathways for moving forward". We highlighted hurdles and solutions to hurdles for a case study analysis of zooplankton data in the Gulf of Alaska, and shared information about collaboration and synthetic analyses tools and technology.

Colette Ward (post-doc): The goal of Ward's project is to assess how the Gulf of Alaska and PWS food webs have changed as a whole since the early 1980s. This work will (i) identify patterns of energy flow (e.g., what are the primary pathways of energy flow, what is the relative importance of benthic and pelagic pathways, and do these show evidence of spatial and temporal patterning?), and evaluate (ii) how natural and anthropogenic phenomena (e.g., atmospheric forcing, climate change, EVOS, commercial harvest) have influenced these patterns, and (iii) how these patterns shape food web structure and function (e.g., trophic control, topological patterns of biomass accumulation, ecosystem stability).

Because this work relies on the availability of time series at all levels of the food web, work in 2015 focused on identifying locations in the Gulf of Alaska that have been sampled across as many trophic levels and years (in the same season) as possible, particularly the five years preceding and following EVOS. Several large multi species data sets encompassing trophic levels from plankton through fish predators have been processed (including sorting, aggregation, and adding higher-order taxonomic information), each yielding 10 - 40 unique time series. Data collection, collation, and cleaning are nearing completion and preliminary analyses are underway.

Resultant data sets are contributing to analyses of several working group projects described above. Ward is also involved in collaborations with R. Blake and J. Couture (described above) and with data collection, collation, and analyses for several working group projects.

Deliverable/Milestone	Status
Assess year 3 data sets and metadata submitted through AOOS	February 2015; Completed; missing data sets have been identified, and contact initiated to obtain additional data.
Submit input for five-year plan for FY17-22	August 2015; Completed (not participating)
Participate in LTM program PI meeting	November 2015; Completed
Create synopsis of FY15 synthesis WG meetings, draft and submit publications	December 2015; Synopsis completed (inline); data collation, analysis, and modeling in progress on synthesis working groups and are on-track under the revised time plan (in which working groups operate in FY15 and FY16).

8. Coordination/Collaboration: *See*, Reporting Policy at III (C) (8).

a. Coordination within and between Council funded programs

This project continues to be highly collaborative within GWA and between programs. The continued management and addition of data are done in coordination with Alaska Ocean Observing System (AOOS) and Axiom Consulting, along with the GWA investigators. Historical data collation is ongoing. Additionally, data from syntheses are shared on the AOOS data platforms and include data from various synthesis projects.

Both NCEAS working groups include members from the GWA and/or Herring Research and Monitoring (HRM) programs as well as various local and governmental agencies: ADF&G, NOAA Alaska Fisheries Science Center, and USGS.

b. Coordination with other Council funded projects

Data collation activities continue to engage various historical *Exxon Valdez* Oil Spill Trustee Council- (EVOSTC)-funded projects as well as external agencies. FY16 will see a final major push to obtain historical data from these projects, and all of this data will be deposited in the AOOS data platforms.

c. Coordination with management agencies and Trustees

None during this reporting period.

9. Information and Data Transfer: *See*, Reporting Policy at III (C) (9).

In addition to continued data maintenance and sharing through the historic EVOS data site, this year's data and progress were shared at conferences, meetings and through the internal GWA program Oceans Workspace. Data syntheses and visualizations were presented at synthesis meetings throughout the year as well the GWA annual meeting in Anchorage. Combined data sets and spatial and temporal representations of data available are also shared with the GWA and HRM programs through the Oceans Workspace as well as the historical data portal. In addition, we are continuing work to collate data for the two NCEAS synthesis groups, with a major effort on collating fisheries independent data from large regions of the Gulf of Alaska from the ADF&G.

10. Response to EVOSTC Review, Recommendations and Comments: *See*, Reporting Policy at III (C) (10).

None needed.

11. Budget: *See*, Reporting Policy at III (C) (11).

Please see provided program work book.

The projected budget allocation for 2016 is as originally budgeted, with some changes in personnel details. Some expenditures for 2015 were delayed because, as expected, the synthesis working groups and synthesis postdocs were selected during 2014 but did not start activities until January, 2015. Both synthesis working groups and postdocs are actively meeting and plan their final meetings and activities in FY16. Thus, we expect to rollover these expenses so that the postdocs and working groups will take place in years 4 and 5 (rather than years 3 and 4 as originally planned). We still have not been utilizing the software engineering funds after our initial work on provenance was completed as we need a more effective plan to integrate with AOOS and Axiom infrastructure. During the mid-year plan work plan, we requested a re-budget to reallocate some of these funds to the continued effort of data collation. These retargeted salary funds are being used to fund the project data manager and students to do data entry, collation, and preservation work for historical EVOSTC project data. A small amount of funding remains for the software engineer to support

Axiom in FY16 to enable the AOOS systems to fully interoperate with DataONE, which will allow the historical data portal and the Gulf of Alaska Data Portal to be merged. We plan to expend the remaining software engineering funds in year 5 after another discussion with Axiom about how to best continue to collaborate.